Micro-Combined Heat & Power Generation

part 01

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With a strong expertise in centralized energy generation Asja Group decided years ago to move into the business of decentralized energy generation with a strong awareness it will play an essential role in the years ahead.

Through the daughter company TOTEM ENERGY, Asja Group has become a specialist in Onsite Energy Generation products and particularly in Micro Combined Heat and Power generation.

Its flagship product is the TOTEM micro CHP.
Our energy environment is changing rapidly as Governments globally strive to make cost-efficient use of resources while enabling the emergence of a low carbon economy. Innovative policy is crucial to enabling the emergence of those technologies that will deliver this outcome.

Micro Combined Heat and Power (μCHP), a cost-effective and flexible low carbon solution that generates heat and electricity on-site, can support the transformation of the energy system and the achievement of relevant policy objectives, including environmental ones. Widespread μCHP deployment can transfer a significant part of electricity generation at local level, creating significant benefits for the energy system and for consumers.
CURRENT TECHNOLOGIES

μCHP

domestic level

Fuel Cells Solid Oxide (SOFC)
20000 €/kWe

Stirling
10000 – 16000 €/kWe

Motor-bike engines
3500 - 5000 €/kWe

gyms, small hotels, cottages

Automotive engines
1500 - 3000 €/kWe

hotels, swimming pools, industrial facilities

Automotive engines
1000 – 2500 €/kWe

Micro turbines
3000 – 4000 €/kWe

Industrial engines
2500 – 3000 €/kWe

0-6 kWe

10-20 kWe

25-50 kWe
μCHP
IN THE WORLD
μCHP BASED ON INTERNAL COMBUSTION ENGINES

CUSTOMER

MICRO-COMBINED HEAT&POWER

< 50 kW

Power generator

Engine

Heat exchangers

Catalytic converter

Natural gas
Biogas
LPG

Engine

Power generator

Heat exchangers

Catalytic converter

Natural gas
Biogas
LPG

CUSTOMER
Engine-based μCHP are flexible in terms of fuel type utilisation.

Therefore, renewable gases like biomethane should not be overlooked as the eventual fuel of preference for μCHP.

Renewable gas fuelled μCHP would allow the technology to become part of the portfolio of renewable solutions to attain full decarbonisation of power and heating.
Choose TOTEM, heat is free!

μCHP BENEFITS FOR THE USER

- Economic benefits
  savings on energy bills
- Enabler for District Power and Heating
- Increased security in electrical supply
  (μCHP can also work in "island" mode in the event of blackouts)
- Operation in "Peak-shaving"
  to cope with high power demand for limited time periods
- Increased "Power quality"
  to ensure constant voltage and frequency to safeguard production processes
\( \mu \text{CHP} \) brings savings as the primary energy used is less than that required for the separate production of heat and power.

- **\( \mu \text{CHP} \)**: 313 units of fuel input, 203 units of delivered energy, 100 units of delivered energy.
- **Conventional Methods**: 226 units of fuel input, 222 units of delivered energy.

**Energy Savings**:
- **\( \mu \text{CHP} \)**: 30% saving.
- **Conventional Methods**: 448 units of fuel input, 303 units of delivered energy.
$\mu$CHP PRIMARY ENERGY SAVINGS

Energy Saving:
$$\Delta E_c = E_p - E_c$$

Primary Energy Saving:
$$PES = \frac{\Delta E_c}{E_p} = 1 - \frac{E_c}{E_p} > 0$$

$\mu$CHP

mCHP

$E_c$

$E_t$

$E_e$

Heat demand

Power demand

losses

Boiler

$\eta_t$

Power Station

$\eta_e$

losses

Conventional Methods

$E_t / \eta_t$

$E_e / \eta_e$

$E_p = \frac{E_t}{\eta_t} + \frac{E_e}{\eta_e}$
Aside from an ideal like-for-like heating replacement in individual properties, μCHP is well placed to operate in a modular fashion in a shared environment, benefiting from economies of scale. μCHP is an ideal solution for social housing or for a block of flats and community heating schemes. The modular deployment of μCHP may become the predominant commercialisation means as the decarbonisation targets become more stringent.

Distributed μCHP clusters can jointly make a low emission District Power and Heating.

In fact, μCHP can meet with flexibility the distributed customer demand of heat & power with emissions up to 20 times lower than modern boilers and 20% less CO₂ over centralized electricity generation.
Benefits for the balance of payments and decreased dependence on import of fossil fuels

- Reduced CO₂ and noxious emissions (reduced dead and health costs)
- Decreased occurrence of overload conditions in the transmission lines, with increased resilience of the electric grid
- Reduced transmission and distribution losses
- Encouragement of new energy providers liberalization of the energy sector
μCHP BENEFITS FOR THE ELECTRICAL SYSTEM AND FOR THE COUNTRY

- Widespread μCHP uptake could complement significant investment in centralised generation, or indeed transfer a considerable proportion of electricity generation from big centralised power stations to the local level.

- About 7% of all generated electricity is lost when it is transported to consumers as a result of transmission and distribution losses. μCHP penetration would allow the efficient generation of electricity by alleviating losses of electricity.

- In an environment that favours a more important role for local energy generation, μCHP is the most controllable distributed energy technology. The power output of μCHP can allow enhanced viability in local power generation as a result of its flexibility and natural fit with key renewable solutions and domestic electricity demand.
With the deployment of smart meters and the smart grid coupled with improvements in energy storage, \(\mu\text{CHP}\) flexibility would generate innovative possibilities to incorporate the demand side more actively in power system operation (prosumers) with considerable benefits.
The change in the Building Regulations by the end of the decade that will require any replacement of heating system to achieve a carbon reduction improvement vs. condensing boilers has the potential to establish a vibrant low carbon heating market.

Such change would generate a level playing field for low carbon heating products, including 𝜇CHP.

The power generated by the 𝜇CHP can be used by a Heat Pump to produce additional heat or to operate as a chiller.

The combination of 𝜇CHP + Heat Pump can serve as a simple means of readily upgrading the existing stock of residential gas boilers and can integrate with legacy high-temperature heating systems (e.g. radiators, pumps)

The global efficiency of the 𝜇CHP + Heat Pump systems can be as high as 160%:

100 energy units of natural gas become 160 units of heat to the end user
μCHP AND HEAT PUMP
FULL HEAT

μCHP and HEAT PUMP (full heat)

Natural gas

0.47 €/m³

mCHP 25 kWe
0.175 €/kWh

Heat Pump P 70 kW
0.076 €/kWh

Heat Pump alone

0.175 €/kWh

0.042 €/kWh

-45%

Vs

Heat Pump 140 kW

0.076 €/kWh

0 €/kWh

heat

heat

hydronic skid
μCHP AND HEAT PUMP
HEAT & COOL

mCHP and HEAT PUMP (heat&cool)

-50% (heat for free)

Vs

Heat Pump and Boiler

0.175 €/kWh

0.058 €/kWh

0.47 €/m3

0.058 €/kWh

0 €/kWh

0.055 €/kWh

mCHP 25 kWe

Heat Pump 60 kW

Heat Pump and Boiler

Natural gas

Heat

Hydronic skid

Boiler

Natural gas

Power

Cool

Heat

Power

Cool
The first μCHP was patented in 1977 by FIAT with the trademark TOTEM (15 kWe).

Growing demand for energy efficiency solutions

Asja Group acquired TOTEM brand and started the TOTEM 2.0 micro CHP development

Launch of the New TOTEM (10-20-25 kW)
«...Now a small co-generation unit, developed and marketed by Fiat in Europe and called TOTAL Energy Module, or TOTEM, is available in the U.S. Through Brooklyn Union Gas Co. In New York City...»
TOTEM
INSIDE (1/2)
The innovative technologies developed to meet the emission limits of Euro6, ensure that TOTEM emissions are 20 times lower compared to a condensing boilers (CO < 10 mg/Nm$^3$ and NOx < 10 mg/Nm$^3$). As such TOTEM is compliant with the most stringent national standards.
Fiat Chrysler Automobiles engines and Magneti Marelli technologies

Multi fuel
methane, biomethane and LPG

Reliable
with high level of efficiency over time

Short payback
2 - 4 years due to savings on energy bills (heat and power)

Indoor / outdoor
installation inside and outside

Operation
single and cascade operation; 50 or 60 Hz

<table>
<thead>
<tr>
<th>MODEL</th>
<th>TOTEM 10</th>
<th>TOTEM 20</th>
<th>TOTEM 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated electric power</td>
<td>kW</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Rated thermal power</td>
<td>kW</td>
<td>21,6 (25,2°)</td>
<td>41,9 (48,5°)</td>
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<tr>
<td>Electrical efficiency</td>
<td>%</td>
<td>29,6</td>
<td>31,2</td>
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<tr>
<td>Total efficiency</td>
<td>%</td>
<td>93,6 (104,3°)</td>
<td>96,5 (106,8°)</td>
</tr>
<tr>
<td>Engine</td>
<td></td>
<td>Fiat Fire 1400 cc</td>
<td></td>
</tr>
<tr>
<td>Engine Control Unit</td>
<td></td>
<td>Magneti Marelli</td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td></td>
<td>methane, biomethane, LPG</td>
<td></td>
</tr>
<tr>
<td>Fuel consumption (CH₄)</td>
<td>Nm³/h</td>
<td>3,31</td>
<td>6,28</td>
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<tr>
<td>Emissions (NOₓ)@5%O₂</td>
<td>mg/Nm³</td>
<td>≤ 10</td>
<td></td>
</tr>
<tr>
<td>Emissions (CO)@5%O₂</td>
<td>mg/Nm³</td>
<td>≤ 10</td>
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</tr>
</tbody>
</table>
**Model**

<table>
<thead>
<tr>
<th>Feature</th>
<th>TOTEM 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Electrical Power</td>
<td>kW</td>
</tr>
<tr>
<td>Rated Thermal Power</td>
<td>BTU kW</td>
</tr>
<tr>
<td>Net electrical efficiency (LHV)</td>
<td>%</td>
</tr>
<tr>
<td>Total efficiency (LHV)</td>
<td>%</td>
</tr>
<tr>
<td>Inlet water temperature</td>
<td>°F / °C</td>
</tr>
<tr>
<td>Engine</td>
<td></td>
</tr>
<tr>
<td>Engine Control Unit</td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td></td>
</tr>
<tr>
<td>Black-out start capability</td>
<td></td>
</tr>
<tr>
<td>Input power rate (LHV)</td>
<td>BTU (kW)</td>
</tr>
<tr>
<td></td>
<td>Th/hr</td>
</tr>
<tr>
<td>Input power rate (HHV)</td>
<td>BTU (kW)</td>
</tr>
<tr>
<td></td>
<td>Th/hr</td>
</tr>
<tr>
<td>Gas pressure requirement</td>
<td>W.C.</td>
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<tr>
<td>Emission settings (NOx)@ 5% O₂</td>
<td>lb/MWhr</td>
</tr>
<tr>
<td>Emission settings (CO)@ 5% O₂</td>
<td>lb/MWhr</td>
</tr>
</tbody>
</table>

- **Modulation**
  From 7.5 - 25 kW of electricity and 15 - 57 kW of heat. Electricity generated matches customer’s demand without exceeding the required need.

- **Black-out start**
  Working while grid failure or power outage. In black-out start mode TOTEM can be fueled either with natural gas or propane.

- **Single phase ready**
  Through the 3+1 wires inverter it can supply three single phase sub grid at once.

- **Emissions**
  TOTEM emissions are up to 20 times less than a condensing boiler.

*Referred to the input water temperature 95°F (35°C)
The TOTEM is the first $\mu$CHP that is awarded with the mark of an accredited institution.

Technical performances, measured by Micro-Cogeneration laboratory of Politecnico di Milano, are verified by TÜV Rheinland Italy that also certified TOTEM’s compliance with the most stringent technical safety regulations.

UL certification will be granted within August 2017.
Production plant is located in Turin (Italy). It is over 2,100 m² area designed according to the maximum efficiency standards: all taking place within that area, from research and development of new models to the production, assembly and testing, is characterized by a rational use of energy produced and consumed.

Production capacity is currently set up to 600 units per year.
Micro-Combined Heat & Power Generation

part 02 | TOTEM @ WorldWide

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APPLICATION

- Wellness centers
- Accommodations
- Restaurants
- Healthcare
- Residential
- Public
- Agricultural sector
- Distribution
- Small/medium industry
BUSINESS CASE
CONDOMINIUM | PAYBACK CALCULATION

Annual energy cost without TOTEM
Heat (38,383 therm/year) 137,015 €
Power (496,904 kWh/year) 112,052 €

Solution
TOTEM 20 × 2
Working hours 4,917

Annual energy and operation cost with TOTEM
Heat 86,086 €
Power + TOTEM Operations cost 131,166 €

Cumulative net savings for 10 years 209,250 €
Payback Time* 3.4 years

* With reference to energy prices applicable to Italy. TOTEM unots w/o black start feature.
**BUSINESS CASE**

**SWIMMING POOL | PAYBACK CALCULATION**

Annual energy cost without TOTEM

Heat (39,247 therm/year)  78,621 €

Power (267,045 kWh/year)  49,817 €

Solution

TOTEM 20  x 1

Working hours  8,760

Annual energy and operation cost with TOTEM

Heat  54,937 €

Power + TOTEM Operations cost  53,465 €

Cumulative net savings for 10 years  144,870 €

Payback Time*  2.7 years

* With reference to energy prices applicable to Italy. TOTEM unots w/o black start feature.
SWIMMING POOL
POWER DEMAND COVERAGE
HOTEL
REFERENCE CASE

Hotel Du Cheval Blanc

Unit type
TOTEM 20

Number of units
2

Fuel type
Natural Gas

Application type
Tourist accommodation

Location
Northern West | Italy
HOTEL & SPA
REFERENCE CASE

Hotel Weiss

Unit type
TOTEM 20

Number of units
1

Fuel type
Natural Gas

Application type
Tourist accommodation

Location
Angermünde | Germany
RETIREMENT HOUSE
REFERENCE CASE

Retirement House Sant’Anna

Unit type
TOTEM 20

Number of units
1

Fuel type
Natural Gas

Application type
Healthcare

Location
Eisenach | Germany
STUDENT ACCOMODATION
REFERENCE CASE

Unit type
TOTEM 10

Number of units
1

Fuel type
Natural Gas

Application type
Residential

Location
Luton, London | United Kingdom
PUBLIC REFERENCE CASE

Fire station

Unit type
TOTEM 20

Number of units
1

Fuel type
Natural Gas

Application type
Public

Location
London | United Kingdom
Drivers

- CHP supportive policy development last 15 years
- From 2012 - 2015 in the range from 10 - 50 kWel 6,937 units were installed (192 MW el)
- BAFA incentives (major CHP incentive in the country; incentive amounts up to €4.375/unit)
- KWKG incentives (€ 0,04/kWh for self consumption in addition to TOTEM generation savings or € 0,08/kWh for selling electricity back to the grid)
- CHP awareness and acceptance by end users are the highest in GE among other EU countries

Opportunities

- In 2016 the last amendment has been launched to CHP law to make conditions more favorable to self consumption
- Need to replace mCHP units installed 10 - 15 years ago
Drivers

- Increasing power prices
- Reduced Ghg emissions
- Building regulations 2010 (legal binding requirements); micro CHP is one of the technologies that is allowed by LZC (Low and Zero Carbon Energy Source) to meet building regulations

Opportunities

- Up to 10 million new homes will be needed by 2050
- Existing stock needs boiler replacement; micro CHP is ease of retrofitting
Drivers

- Cut-Down in electricity expenses
- Reduced GHG emissions (Obama plan)
- Absolute product for boiler replacement (boiler replacement program to meet the emission limit)
- State supportive Government polices (payback is 1 - 2 years)
- Natural gas discounted rate (in some states) for cogeneration
- Promoting and supporting mCHP by gas utilities

Opportunities

- Boiler replacement market
- Residential/commercial applications

Shown are the best locations for Micro CHP based on payback, policies, net metering rules, discounted natural gas prices, length of heating season, emissions regulations and an experienced dealer network.
Drivers

- Rising energy cost
- Long heating season (up to 10 months)
- Advanced CHP technology is more accessible for properties
- 7% of electricity is produced using cogeneration
- Supportive Government policies (cover up to 80% of investment cost)
- Recurrent grid outages
- Need to reduce grid demand and improve infrastructure cost and time effective

Opportunities

- Real estate investment companies
- Residential/commercial applications
Drivers

- Growing economy, LNG and LPG network and reserves
- Existing projects of RES and energy efficiency
- Support country’s economic growth (power and heat supply for textile, food, chemical and commercial plants)
- Urgent need for energy supply Limited access to electricity
- Avoiding distribution losses which represents 10-12%
- Creating reliable electricity supply

Opportunities

- Residential buildings, hospitals and schools
- Small commercial industries
- Most attractive states: Morocco, Jordan, Egypt and South Africa
Drivers

• Efficient urban planning - migration to urban areas are increasing, need to improve energy efficiency and security in new building and retrofits.
• Decrease energy import - promoting energy efficiency gives possibility to meet energy needs without expensive import.
• Reducing - GHG gases and other environmental and social impact.
• More and more adopting incentives to support RES and energy efficiency (ex. Bosnia and Herzegovina, the guaranteed prices for the purchase of electrical energy from facilities using RES and CHP).

Opportunities

• Excising opportunities for large CHP and biofuel
• Micro CHP without incentives bring to 7-8 years payback
• Additional study needed and possible pilot projects
Asja is a member of RES4MED, a non-profit Association established in 2012 for the development of renewables in the Mediterranean Area, with a particular focus on the Countries of Maghreb. Mr. Re Rebaudengo is Vice President of RES4MED.
TOTEM Energy production plant visit
Thank you for your attention

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